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MUNICIPAL AND INDUSTRIAL WATER REQUIREMENTS
WALLISVILLE RESERVOIR TRINITY RIVER TEXAS

Public Health Service
Dallas, Texas

February 1960

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WALLISVILLE RESERVOIR

Trinity River
Texas

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DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII

In cooperation with the

DEPARTMENT OF THE ARMY
U. S. Army Engineer District-Galveston, Texas

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INTRODUCTION

In a letter dated June 8, 1959, the District Engineer, Fort Worth District, Corps of Engineers, requested the Region VII Office, Public Health Service, to recommend prospective needs for municipal and industrial water supply in the vicinity of the Trinity River Basin and to determine the economic value of meeting these needs from the proposed Wallisville Reservoir. This study was made in accordance with the provisions of the Memorandum of Agreement dated November 4, 1958, between the Department of the Army, and the Department of Health, Education, and Welfare, to provide assistance in implementing the Water Supply Act of 1958.

The assistance and cooperation of the following named persons and organizations were very important factors in compiling the data used in the study and are hereby acknowledged:

Professor I. W. Santry, Jr.
Civil Engineering Department
Southern Methodist University

Texas State Department of Health

Bureau of Business Research,
University of Texas

Texas Board of Water Engineers

U. S. Department of the Interior
Bureau of Reclamation

Mr. H. R. Norman, Brown and Root, Inc.

Public Works Department, Houston, Texas

Mr. R. Taylor, Layne-Texas Co.

Public Works Department, Dallas, Texas

SUMMARY AND CONCLUSIONS

1. The geographical area included in this study comprised the counties of Harris, Galveston, Chambers, and Jefferson, and part of Liberty County.
2. The study area has experienced a fantastic rate of economic and industrial development and corresponding population growth in the recent past. If adequate supplies of water are made available at reasonable cost, it is believed that its growth will continue at a rapid rate.
3. Projected water supply requirements for the area are 650 mgd in 1965 and 3,874 mgd by 2010.
4. The full utilization of all fresh water supplies in the area, including use of maximum feasible storage in Wallisville Reservoir, will be needed within the next fifty years.
5. In view of the indicated need for development of all possible sources within fifty years, and in consideration of special circumstances (more fully described herein), it was deemed advisable to depart from the "alternate cost" method, and to use a value for Wallisville water based on a contract price for water in Livingston Reservoir. On the latter basis, it is considered that a reasonable value for Wallisville water is 6.75 mills (\$0.00675) per thousand gallons.

DESCRIPTION OF THE STUDY AREA

Geographic

The proposed Wallisville Dam site is located on the Trinity River in the vicinity of Wallisville, Texas, a few miles above its point of discharge into Trinity Bay. Figure 1 shows the location of the project and an outline of the area studied as a potential "market" for Wallisville water.

The study area, or demand area, consists of Harris, Galveston, Chambers, and Jefferson Counties and that part of Liberty County lying south of the upper end of Wallisville Reservoir. The boundaries of the study area were, of necessity, chosen arbitrarily and may be subject to change. Among the factors considered were the potential demand for water, feasibility of transmission from Wallisville, amount and character of present and future development, and the apparent advisability of encompassing more than the relatively small area of the Trinity River watershed below the reservoir site. Houston and Harris Counties were included especially because of the active interest of the City of Houston in obtaining Trinity River water. General adherence to county lines facilitated the correlation of available data on population and water use.

The study area lies within the Gulf Coastal area of Texas and is characterized by low, grass-covered plains. Two major rivers, the Trinity and the San Jacinto, traverse the area, and the Neches River forms its eastern border.

Economics

There is a wide diversity in the economies of the different parts of the region. Harris County, in which the City of Houston is located, is mainly an industrial county, with some agriculture. Tonnage wise, the Port of Houston is one of the largest seaports in the United States. Galveston County depends largely on deep-water shipping and Texas City industry for its economy. Jefferson County has a balanced economy maintained by agriculture, oil, and industry. Liberty and Chambers Counties are primarily agricultural.

The Counties of Harris, Galveston, and Jefferson are heavily populated, the population being principally urban in character. Liberty and Chambers Counties are less densely settled and are primarily rural in character. Population trends have been upward throughout the study area, with Harris, Galveston, and Jefferson Counties showing the most rapid growth. For example, the 1940 population of Harris County was 528,961, and its 1950 population was 806,701, an increase of 52.5 per cent in ten years. It appears reasonable to assume that a high rate of growth may be expected in the future.



FIGURE 1

Present Water Supplies

Present water requirements of the area are supplied, in most cases, from ground water aquifers. The principal sources of ground water are the Lissie and associated formations. The period from 1931 through 1954 saw a progressive decline in static water tables, ranging from 20 to 200 feet. The completion of Lake Houston Dam and resulting increased use of surface water in the Houston area led, in 1954, to the first decrease in ground-water pumping in that area since 1941. As a result, some recoveries of water levels have been noted since that time. A general subsidence of the land surface over a large part of the Houston area has been attributed to the declines in artesian pressures.^{1/}

With the exception of Jefferson County, where chloride concentrations are high, the ground water in the area is generally of good quality for water supply purposes.

Port Arthur and Beaumont, in the Neches River Basin, derive their water supply from surface sources. A portion of Houston's supply is surface water from Lake Houston on the San Jacinto River.

From a study of data obtained from the Texas State Department of Health and other sources, it is estimated that the combined capacity of all existing water systems in the

^{1/} Wood, Leonard A., Bulletin 5602, Texas Board of Water Engineers, February 1956.

study area is on the order of 396 mgd. This includes both ground and surface water supply systems. As will be discussed later in this report, it is further estimated that full utilization of this capacity will be required sometime before 1965, to meet increasing water requirements.

Present Water Use

An idea of the magnitude of present water use can be obtained by examination of Table 3 (Appendix). This table gives the average daily pumpage in mgd for the 21 principal cities of the area, as reported to the Texas State Department of Health for the year 1958. Total for the 21 cities was 136 mgd.

A large number of industries in the demand area obtain their water from an adjacent municipality. However, some industries, especially those with heavy demands, have developed their own supplies. For example, industries in the latter category are using an estimated 100 mgd in the Houston area.

FUTURE GROWTH AND WATER REQUIREMENTS

Population

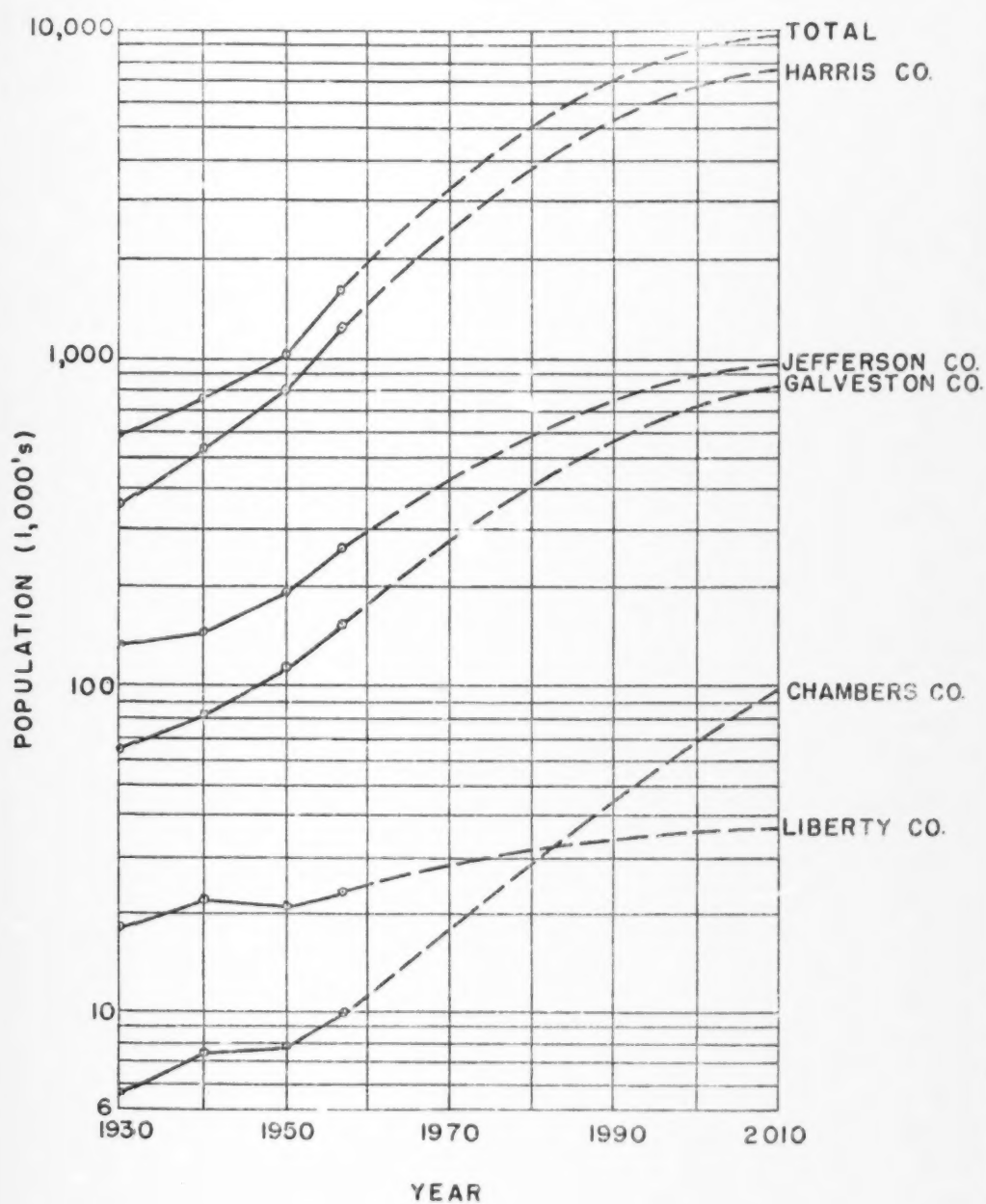
Figure 2 shows past and predicted future populations for each county (or portion thereof) and for the over-all area, for the period from 1930 to 2010. The historical population figures (and estimates for the year 1957) were obtained from the U. S. Bureau of the Census.

The population growth curves presented in Figure 2 are subject to the inaccuracies inherent in such long-range projections. In addition to historical records, they were based on consideration of type and density of population, the existence of raw materials for basic industry, notably petroleum and petrochemical, market potential, transportation facilities, including the intracoastal canal and deep-water channels, the labor market, and the present degree of saturation. It was assumed that water supply, adequate in quantity and quality, will be made available at reasonable cost, to meet the requirements of the predicted growth. Although a direct comparison cannot be made because of boundary differences, consideration was also given to the studies made by the Bureau of Business Research of the University of Texas, and published in various reports issued by the Bureau (see Bibliography).

Liberty County has experienced developments in oil and agriculture in recent years, which have reversed the previous declining population trend. Its growth may be further stimulated by the provision of inland navigation on the Trinity River. It is expected that it will continue to grow, although at a rate substantially lower than the other counties of the area.

Jefferson County is a highly industrialized area with an economy based on oil production and processing, manufacturing, agriculture, and shipping. Beaumont is an important seaport, Port Arthur is noted for its oil production, and Port Neches has extensive industry.

Chambers County is primarily agricultural at the present time. There is a fair amount of oil, rice, and cattle production in the county. In the future, there will be a need for expansion of the deep-water port facilities for the area. It is believed that a ship channel will probably be extended along the shore of Trinity Bay, with docking and transfer facilities near the mouth of the Trinity River. This is expected to stimulate development in Chambers County and accelerate its future growth rate.



POPULATION TRENDS

U.S. DEPARTMENT OF
HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE 2

Harris County, the fastest growing county under study, has mainly an urban population, centered in the City of Houston, the largest Texas city. Houston is an extremely important seaport and the principal manufacturing center in the state. The leading industries to be found in the Houston area are petroleum, cotton, shipping, meat packing, and chemical. Also in Harris County are found cattle, oil, and some timber industries. Houston's past and present growth rates have been remarkably high, and it is believed that this high rate can be expected to continue, although progressively diminishing, through the study period of the next fifty years.

Galveston County, too, has a highly urbanized population. The port city of Galveston and the industrial area of Texas City are located in this county. It is anticipated that the petrochemical industries in Texas City will expand, and that the population of this county can be expected to grow as depicted on Figure 2.

The predicted populations for the entire study area are 2,446,000 for the year 1965 and 9,787,000 by 2010.

Water Requirements

For the purpose of this study, municipal (or domestic) and industrial water requirements have been divided into three categories:

- (1) Fresh-water use by basic industry
- (2) Brackish water used by basic industry
- (3) Other fresh water requirements, called "Domestic Use" for brevity and including the needs for residential, municipal, nonbasic industries, and miscellaneous purposes not included in the first two categories.

As the term is used herein, Basic Industry refers to an industry which produces goods for sale outside the area and thus brings income into the area. Petroleum refineries and petrochemical plants are examples of this type of industry.

There is a wide diversity in the water requirements of basic industries, depending upon the processes involved. For this reason, correlation of basic industrial water needs with population must start with an appraisal of the scope and nature of the various basic industries. The quality of water required will also depend upon the purpose for which it is used.

Predicated on an increasing awareness of the importance of conservation of fresh water (and continuing increase in its cost), it has been assumed that 80 per cent of the water requirements of basic industry will, in the future, be met by brackish water and 20 per cent by fresh water.

The increase in domestic water use in this country has been reflected in two ways, a greater gross demand as population increased, and a continuing increase in per capita consumption. It is generally agreed by those who have studied the problem that per capita rates will continue to rise in the future, reflecting a better standard of living, wider application of modern sanitation standards, and other factors.

Projections of the expected trend in per capita use were made for each county of the study area. Past trend and present base for each county were obtained from data collected by the Texas State Department of Health. These data were plotted and future trends projected graphically, guided by past record, judgment, and the predicted national trend.

Basic industrial water use was correlated with population by using data taken from Water Requirements Survey for Texas, Bulletin 5910, prepared by the Bureau of Business Research, University of Texas, and published in July 1959, by the Texas Board of Water Engineers. For that publication, an inventory

and classification of basic industries were made, together with a tabulation of quantity of water required per unit of product by each industry. Using a combined interrelationship of water quantities per unit produced, man-hours per unit, total employment per basic industry employee, and total population per worker, a per capita use figure was obtained for each area. The future per capita use figures for basic industry reflect the net result of two predicted offsetting trends, a decrease in man-hours per unit of product, and increased efficiency of water use; that is, a reduction in amount of water per unit of product.

Table 1 summarizes the results of the study of population and water use for the terminal year of projection, 2010, and also gives figures for the intermediate year 1965. The water requirement projection is also shown graphically on Figure 3 (Appendix).

Table 1 - Total Water Demand

County	Design Population	Domestic Use GPCD	Basic Industrial Use GPCD	Average Daily Fresh Water Requirement (mgd)	
				Domestic	Industrial
Year - 1965					
Chambers	15,300	140	4,730	2.1	14.5
Galveston	220,000	160	530	35.2	23.3
Harris	1,800,000	177	372	318.0	134.0
Jefferson	385,000	137	829	52.8	63.9
Liberty	<u>26,000</u>	123	576	<u>3.2</u>	<u>3.0</u>
Total	2,446,300			411.3	238.7

TOTAL DEMAND BY 1965 - 650.0 mgd

<u>Year - 2010</u>					
Chambers	100,000	187	8,167	18.7	163.2
Galveston	860,000	230	972	198.0	155.0
Harris	7,800,000	249	611	1,940.0	953.0
Jefferson	990,000	190	1,248	188.0	247.0
Liberty	<u>37,000</u>	180	603	<u>6.7</u>	<u>4.4</u>
Total	9,787,000			2,351.4	1,522.6

TOTAL DEMAND BY 2010 - 3,874.0 mgd

THE TRINITY RIVER AS A POTENTIAL SOURCE OF WATER

Historical Record of Flows

The flow of the Lower Trinity River has been measured by the U. S. Geological Survey at Romayor, Texas, (mile 94) since 1924. Incomplete records are also available since October 1938 at Liberty, Texas, (mile 40).

The 33-year average flow at Romayor was 7,333 cfs. Maximum discharge of record was 111,000 cfs, on May 9, 1942, and minimum flow was 102 cfs, August 24 and 25, 1956. For the record flood of May 1942, the maximum discharge at Liberty, was 114,000 cfs, on May 12. Minimum flow at Liberty is affected by tidal action, and measurements are not available.

Quality of Water

The Trinity River below Livingston is generally of good quality for public water supply, except during periods of flood flow. At these times, sludge deposits are broken loose and organic matter that has collected on high ground is washed into the river.

At present, there are no industrial organic pollution loads entering the river in the lower reach. Reliable information is not available on the discharge of inorganic wastes to this portion of the river. However, chemical analyses of the water indicate that such wastes, if present, are not causing significant deterioration of quality.

Table 2 gives an inventory, based on 1958 estimates, of the municipal organic wastes entering the river at or below the City of Livingston.

Table 2 - Present and Future Sources of Organic Pollution

<u>City</u>	<u>Type of Waste</u>	<u>Population Equivalents</u>	
		<u>1958</u>	<u>2010</u>
Dayton	Municipal	800	600
Liberty	Municipal	2,550	1,650
Livingston	Municipal	200	2,220

The last column of the above table shows estimated waste loads to be expected by the year 2010. By that time, it is assumed that all towns will be achieving at least 85 per cent reduction of waste loads by treatment.

Data on chemical quality of the water are available for a sampling point near Romayor, Texas. Samples have been collected by the U. S. Geological Survey for a period of 16 years, since 1941, with some gaps in the record. Average concentrations for a ten-year period were as follows:

Sulphates	39 ppm
Chlorides	62 ppm
Dissolved Solids	279 ppm

Additional samples have been collected at Liberty, Texas, but only for a few months.

The concentrations of sulphates, chlorides, and total dissolved solids are not of serious magnitude at the present time. However, there is an upward trend in these concentrations, possibly caused by the increased discharge of municipal wastes upstream. It is roughly estimated that the concentrations will fall within the following ranges from now until the year 2010.

Sulphates	70 - 160 ppm
Chlorides	260 - 660 ppm
Total Dissolved Solids	390 - 1,240 ppm

From the foregoing, it may be concluded that Trinity River water now has a quality satisfactory for municipal and industrial use, and this will continue to be true, provided proper discipline is maintained over the disposal of wastes.

Assumed Plan of Operation

From information given by the Corps of Engineers, and according to the terms of an agreement made in 1959 between the City of Houston and the Trinity River Authority, the function of Wallisville Reservoir, insofar as water supply is concerned, will be as outlined below.

Livingston Reservoir (proposed for construction by the Trinity River Authority and the City of Houston) and Wallisville (now being studied by the Corps of Engineers) will be operated as an integral unit. Livingston, with an estimated yield of 1120 mgd for municipal and industrial purposes will be the major storage

reservoir. The downstream Wallisville Dam will serve as a diversion structure for Livingston water. Releases from Livingston will be picked up from Wallisville Reservoir, for transmission to market.

Although the primary regulatory function will be performed by Livingston, it is understood that it is possible to increase the combined yield by providing conservation storage in Wallisville Reservoir, and that the combined feasible yield could be 1200 mgd or more.

Need for Wallisville Water

If the growth patterns given in this and other studies are to take place as predicted, the full utilization of all potential sources of water supply will be required within the next 50 years. This means that there is no "alternate" source of water in the usual sense of the word, since "alternate" implies a freedom of choice. For this study area, it follows that the only freedom of choice will be in deciding the time sequence of utilization of the several sources, and even this freedom must be modified by the priority given to multiple-purpose projects for other purposes. It seems evident that the decision has already been made to utilize the Trinity River and the Livingston-Wallisville Project in the near future.

Value of Wallisville Water

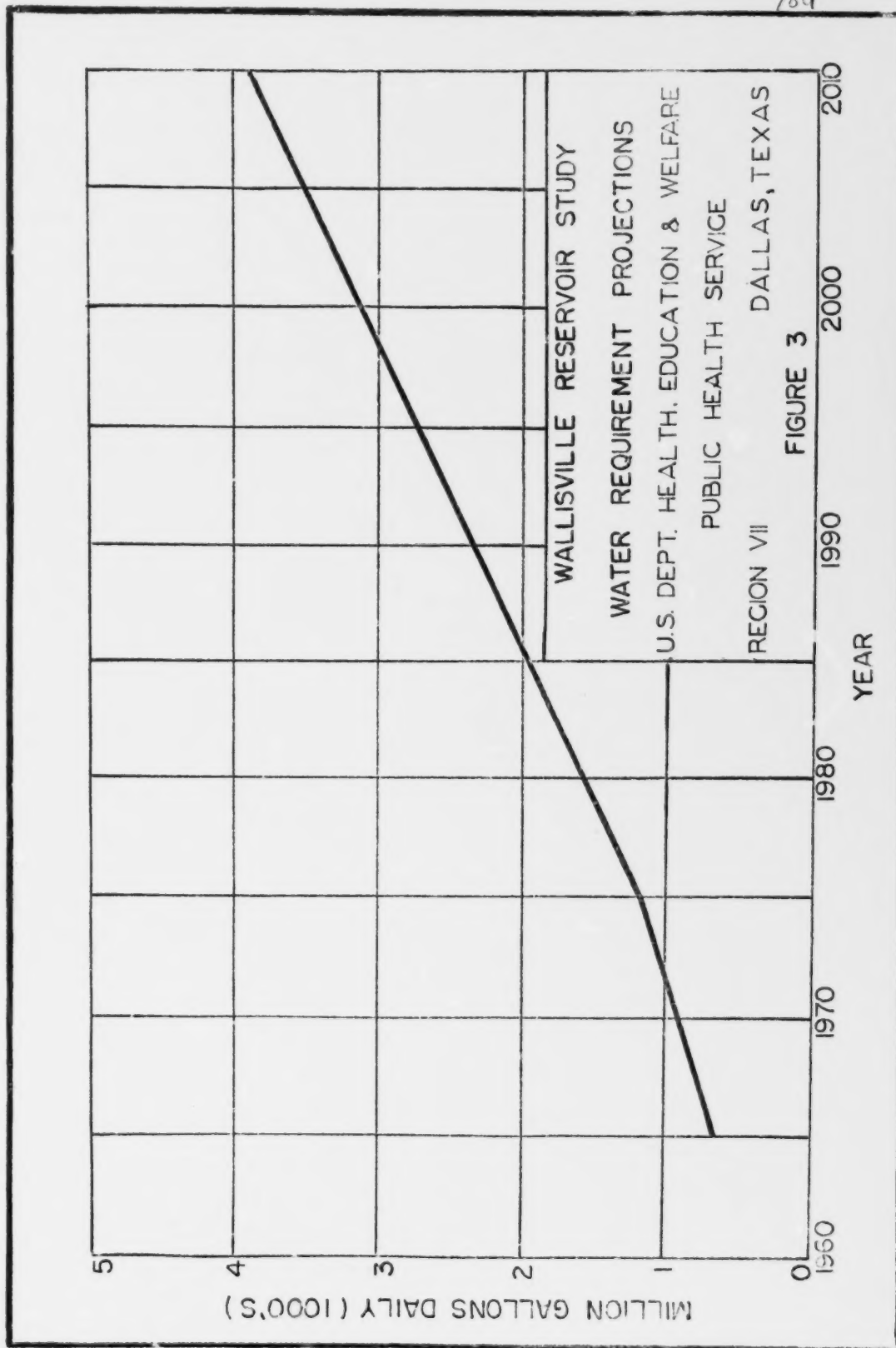
On the basis that Wallisville will be operated as an integral part of a Livingston-Wallisville system, it is concluded that the

value of water in Wallisville is equal to the value of Livingston water, as established by the aforementioned agreement between the City of Houston and the Trinity River Authority. This value is 6.75 mills (\$0.00675) per thousand gallons.

APPENDIX

Table 3 - Present Water Users

<u>City</u>	<u>Source</u>	<u>1958 Daily Use (mgd)</u>
Alvin	Well	0.477
Anahuac	Well	0.118
Angleton	Well	0.528
Baytown	Well	2.630
Beaumont	Surface	12.615
Cleveland	Well	0.316
Danbury	Well	0.041
Dickinson	Well	0.495
Galveston	Well	11.416
Groves	Surface	0.984
Houston	Surface & Well	90.709
Lake Jackson	Well	0.440
League City	Well	0.192
Mount Belview	Well	0.141
Nederland	Well	0.662
Pasadena	Well	4.739
Pearland	Well	0.140
Port Arthur	Surface	6.288
Texas City	Well	2.365
Winnie	Well	0.113
Liberty	Well	<u>0.579</u>
Total		135.988



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